

VEHICLE CHARGING APPARATUS

FIELD OF THE INVENTION

[0001]

The present disclosure relates to a vehicle charging apparatus, and more specifically relates to a vehicle charging apparatus that is installed in, for example, a shop to ensure simultaneously charging a plurality of vehicles.

BACKGROUND OF THE INVENTION

[0002]

There is provided a charging apparatus that ensures simultaneously charging a plurality of vehicles, such as electric vehicles. While the charging apparatus suppresses an entire charging current, the charging apparatus performs a control that preferentially supplies a current to a vehicle having a charge amount that has not reached a certain power amount to shorten a charging period until the certain power amount is charged.

[0003]

For example, in JP 2020-182330 A, a control is performed such that a vehicle having a charge amount that does not reach a charge amount allowing traveling for a certain distance is charged preferentially over a vehicle having a charge amount that reaches the charge amount allowing traveling for the certain distance, and the individual vehicle is charged such that a received power from a system does not exceed a set standard value or maximum demand value.

The maximum demand value is a maximum value of average power usage measured every 30 minutes for the past one year.

[0004]

The technique of JP 2020-182330 A has an effect of reducing contracted electric power corresponding to a demand control. However, the technique premises a configuration that has a function of obtaining information, such as a remaining charge amount and full charge, from a vehicle to which a charger is coupled, and when the charger does not have a function of communicating with

a vehicle, the technique has not been applicable.

[0005]

Therefore, an object of the present disclosure is to provide a following vehicle charging apparatus. While the vehicle charging apparatus performs a demand control, the vehicle charging apparatus can recognize a fully charged vehicle and exclude the vehicle from a priority order of charging even when a charger has a configuration that cannot obtain information, such as a remaining charge amount and full charge, from the vehicle, thereby ensuring efficient charge control.

SUMMARY OF THE INVENTION

[0006]

In order to achieve the above-described object, a vehicle charging apparatus according to a first aspect of the disclosure is provided. The vehicle charging apparatus includes a plurality of chargers for charging vehicles and a charge control unit. The charge control unit collectively controls charging currents of the chargers. The charge control unit provides a threshold of a charge amount to set priority order for the vehicles to be charged. The charge control unit performs a charge control that preferentially charges the vehicle having the charge amount equal to or less than the threshold over the vehicle having been charged to exceed the threshold. The charge control unit obtains received power information from a system and controls vehicle charge such that a received power does not exceed a standard value. The charge control unit removes the vehicle having continued to receive the charging current, which is actually supplied from the charger, smaller than a command value of the charging current for the command value, from a charge target.

According to the configuration, while a demand control that restricts the received power of a commercial power is performed, the vehicle having the charge amount equal to or less than the threshold is preferentially charged. Accordingly, the charging period up to the threshold can be shortened, and even in a situation in which an entire current is restricted, stress felt by a user can be reduced.

Even without obtaining full charge information from the vehicle, whether the vehicle is fully charged can be determined from current information supplied from the charger, and the charge

can be terminated. Accordingly, the fully charged vehicle can be reliably removed from the charge target and efficient vehicle charge can be performed.

The threshold is a charge amount that allows traveling of a distance for, for example, 30 km and is a charge amount that allows going home.

[0007]

In a second aspect of the disclosure, which is in the configuration according to the first aspect, when the received power is predicted to exceed the standard value, the charge control unit performs a control to reduce the charging current starting from the vehicle having the charge amount that has exceeded the threshold.

According to the configuration, the vehicle having the charge amount equal to or less than the threshold is less likely to be affected by a current reduction control, and the charge up to the threshold is prioritized.

[0008]

In a third aspect of the disclosure, which is in the configuration according to the second aspect, the charge control unit allocates the priorities in descending order of the charge amounts, which have been charged from start of the charge, in a group of the vehicles having the charge amount that has exceeded the threshold. The charge control unit reduces the charging current starting from the vehicle having a lowest priority in the group.

According to the configuration, the charging current is reduced from the vehicle having the smallest charge amount among the vehicles having the charge amount that has exceeded the threshold. Therefore, the charge amount of the vehicle that starts charging later does not exceed the charge amount of the vehicle that has started charging previously, and thus the user having the vehicle that takes long time to be charged does not complain.

[0009]

In a fourth aspect of the disclosure, which is in the configuration according to the second aspect, the charge control unit allocates the priorities in order of long charging periods in a group of the vehicles having the charge amount that has exceeded the threshold. The charge control unit reduces the charging current starting from the vehicle having a lowest priority in the group.

According to the configuration, the charging current is reduced from the vehicle having the shortest charging period among the vehicles having the charge amount that has exceeded the threshold. Therefore, the charge amount of the vehicle that starts charging later does not exceed the charge amount of the vehicle that has started charging previously, and thus the user having the vehicle that takes long time to be charged does not complain.

[0010]

In a fifth aspect of the disclosure, which is in the configuration according to any one of the first aspect to the fourth aspect, when the received power falls below the standard value, the charge control unit performs a control that increases the charging current starting from the vehicle having the charge amount equal to or less than the threshold.

According to the configuration, when the received power is equal to or less than the standard value and power remains, the charging current of the vehicle having the charge amount equal to or less than the threshold is increased first, and therefore the charging period reaching the threshold can be shortened and a convenience is satisfactory.

[0011]

In a sixth aspect of the disclosure, which is in the configuration according to the fifth aspect, the charge control unit allocates the priorities in descending order of the charge amounts, which have been charged from start of the charge, in a group of the vehicles having the charge amount equal to or less than the threshold. The charge control unit increases the charging current starting from the vehicle having a highest priority in the group.

According to the configuration, the charging current is increased starting from the vehicle having the largest charge amount among the vehicles having the charge amounts equal to or less than the threshold. Therefore, the charge amount of the vehicle that starts charging later does not exceed the charge amount of the vehicle that has started charging previously, and thus the user having the vehicle that takes long time to be charged does not complain.

[0012]

In a seventh aspect of the disclosure, which is in the configuration according to the fifth aspect, the charge control unit allocates the priorities in order of long charging periods in a group of

the vehicles having the charge amount equal to or less than the threshold. The charge control unit increases the charging current starting from the vehicle having a highest priority in the group.

According to the configuration, the charging current is increased starting from the vehicle having the longest charging period among the vehicles having the charge amounts equal to or less than the threshold. Therefore, the charge amount of the vehicle that starts charging later does not exceed the charge amount of the vehicle that has started charging previously, and thus the user having the vehicle that takes long time to be charged does not complain.

[0013]

According to the present disclosure, even when the demand control that restricts the received power of the commercial power is performed, the vehicle having the charge amount equal to or less than the threshold is preferentially charged. Accordingly, the charging period up to the threshold can be shortened, and even in the situation in which the entire current is restricted, stress felt by the user can be reduced.

Even when the full charge information is not obtained from the vehicle, the full charge can be determined from the current information supplied from the charger and the charge can be terminated. Accordingly, the fully charged vehicle can be reliably removed from the charge target, and the vehicle can be efficiently charged.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG. 1 is a block diagram illustrating an example of a vehicle charging apparatus according to the present disclosure.

FIG. 2 is a flowchart depicting a procedure of allocating priorities.

FIG. 3 is a flowchart depicting a process of determining full charge.

FIG. 4 is a flowchart depicting a procedure of a repetitive process.

DETAILED DESCRIPTION OF THE INVENTION

[0015]

The following will describe embodiments where the present disclosure is embodied in detail with reference to the drawings. FIG. 1 is a block diagram illustrating an example of a vehicle charging apparatus according to the present disclosure. As illustrated in FIG. 1, a vehicle charging apparatus 1 includes a plurality of chargers 2 and a charge control unit 3. Charging cables L1 extending from vehicles 4 such as Electric Vehicles (EVs) are coupled to the plurality of chargers 2. The charge control unit 3 obtains received power information from a smart meter (an electric energy meter) 10 and outputs control signals of electric power to the respective chargers.

[0016]

The charger 2 includes a circuit (not illustrated) that receives the control signal from the charge control unit 3 and increases and decreases a charging current.

The charge control unit 3 includes, for example, a measurement unit 31, a storage unit 32, a charge control unit CPU 34, and a plurality of communication units 35. The measurement unit 31 is coupled to the smart meter 10 via a communication line L2. The storage unit 32 stores, for example, a demand value and a standard value and a threshold described later. The charge control unit CPU 34 determines the charging currents which flow to the respective chargers 2 and controls the respective units in the charge control unit 3. The plurality of communication units 35 communicate with the individual chargers 2.

[0017]

The threshold is a charge amount required for traveling for a certain distance or more, such as 30 km, and is uniformly set by an amount of charging power from start of the charge. Reference numeral 5 denotes a step-down transformer that transforms a high voltage into a low voltage, reference numeral 6 denotes a load, such as an air conditioner, to which three-phase power is supplied, and reference numeral 7 denotes a load, such as an illuminator, to which a single-phase 100/200 V is supplied. To the charger 2, a single-phase 200 V power is supplied.

[0018]

A charge control that charges the plurality of vehicles 4 by the vehicle charging apparatus 1 thus configured is performed as follows. First, the priorities for allocation of the charging currents are set.

FIG. 2 depicts a procedure of allocation of the priorities of the vehicles 4 to be charged, and the description will be given with reference to FIG. 2.

When the vehicle 4 is coupled (a charging plug of the vehicle 4 is coupled) to the charger 2 and a charge start operation is performed, the charge control unit CPU 34 starts charging at a current having a predetermined value. Simultaneously, the priorities are allocated together with the other vehicles 4 to which the charge control has already been performed.

First, the number of vehicles 4 that have the charge amounts equal to or less than the threshold and are not fully charged (the number of unachieved vehicles: n) is grasped (S1), and then the number of vehicles 4 that have the charge amounts in excess of the threshold and are not fully charged (the number of achieved vehicles: m) is grasped (S2).

The charge control unit CPU 34 grasps the charge amount from when the charge to the individual vehicle 4 starts by the charging current and the charging period, compares the value with the threshold, and performs determination.

[0019]

Next, the vehicles 4 in a group that have the charge amounts equal to or less than the threshold and are not fully charged (the number of unachieved vehicles: n) are arranged in the descending order of the charge amounts, prioritized, and allocated from the first to the n^{th} (S3). Subsequently, the vehicles 4 in a group that have the charge amounts in excess of the threshold and are not fully charged (the number of achieved vehicles: m) are arranged in the descending order of the charge amounts, prioritized, and allocated from the $(n+1)^{th}$ to the $(n+m)^{th}$ (S4).

Thus, the prioritization is made from the first to the $(n+m)^{th}$. Note that the charge amount of the first vehicle 4 is the largest and the charge amount of the n^{th} vehicle 4 is the smallest among the first to the n^{th} vehicles 4. The charge amount of the $(n+1)^{th}$ vehicle 4 is the largest and the charge amount of the $(n+m)^{th}$ vehicle 4 is the smallest among the $(n+1)^{th}$ to the $(n+m)^{th}$ vehicles 4. After the priorities are thus allocated, the process proceeds to an increase/decrease control of the current.

[0020]

FIG. 3 is a flowchart of a full charge determination process, and the full charge

determination process will be described with reference to FIG. 3. The vehicle charging apparatus 1 issues a command of charging current to each of the chargers 2, and determination is made by a response to the command from the charger 2.

First, a command value of the charging current is transmitted to the charger 2 (S11). To the command value, information of actual current value supplied from the charger 2 to the vehicle 4 is received as a reply (S12). When the actual charging current value is in accordance with the command value (NO at S13), it is determined that the vehicle 4 is not fully charged and the determination is terminated.

[0021]

When the actual charging current value is smaller than the command value (YES at S13), next, whether the charging current value is further smaller than a specific current value smaller than the command value is determined (S14). When the charging current value is not smaller than the specific current value (NO at S14), it is determined as an error and determined that the vehicle 4 is not fully charged. Accordingly, the determination is terminated.

When the charging current value is smaller than the specific current value (YES at S14), counting starts for a predetermined period (S15). When the predetermined period has elapsed (YES at S17) without recovery of the charging current (NO at S16), it is determined that the vehicle 4 is fully charged (S18) and the process is terminated. The vehicle 4 determined to be fully charged is excluded in the allocation of the priorities depicted in FIG. 2.

However, when the actual charging current becomes the specific current value or more (YES at S16) before the predetermined period has elapsed (NO at S17), it is determined that the vehicle 4 is not fully charged and the process is terminated.

[0022]

FIG. 4 is a flowchart depicting a procedure of the increase/decrease control of current on the ordered individual vehicles 4, and the control will be described with reference to the flowchart. The charge control unit 3 collectively performs the control, and the control significantly changes depending on the current received power with respect to the demand value or the standard value.

Note that the standard value is an electric power value, for example, smaller than the

maximum demand value by 10% and indicates a value set by a consumer to reduce the maximum demand value to reduce a contract charge.

[0023]

The following will describe a case where the standard value is used as a determination criterion for control. Upon receiving allocation information of the priorities (S21), first, when deviation information is equal to 0 (proceeds to the left at S22), that is, when the current received power is approximately equal to the standard value, all charging currents of the vehicles 4 are not changed, the process is terminated and returns to S21, which is the first step, to perform the allocation of the priorities.

The deviation information is a value defined as in the following Formula 1.

Deviation information = Current received power - Standard value... (Formula 1)

[0024]

Next, when the deviation information is a positive value (proceeds downward at S22), that is, when the received power exceeds the standard value, a control to reduce the current is performed. To be exact, when an average electric power in 30 minutes is expected by calculation from the current received power, in the case of determining that there is a possibility of exceeding the standard value, the control to reduce the current is performed.

Specifically, the exceeding current value (a deviation value) is calculated by the following Formula 2 (S23), and a charging current reduction control (S24) is performed in the order starting from the vehicle 4 having the charge amount that has exceeded the threshold and the smallest charge amount.

Deviation value = Deviation information/Voltage ... (Formula 2)

[0025]

The maximum reduction amount per vehicle is smaller one of a value obtained by subtracting a predetermined minimum current value from the present current value and the calculated deviation value (S25). For example, when the deviation value is 10 amperes and the value obtained by subtracting the predetermined minimum current value from the present current value is 5 amperes, 5 amperes are selected, and the control to reduce the charging current of the $(n+m)^{th}$ vehicle 4, which

is the smallest in charge amount among the vehicles 4 having the charge amount that has exceeded the threshold, by 5 amperes is performed. Thus, the vehicle 4 having the smallest charge amount among the vehicles 4 with the charge amount that has exceeded the threshold is the top priority target of the charging current reduction. In other words, the priority of the charge is the bottom.

[0026]

Then, a current value obtained by subtracting the reduced current value from the deviation value is set to a new deviation value (S26), and Steps S24 to S27 are repeated until the deviation value becomes 0 or the processes are performed on all of the vehicles 4, and the control is performed in the orders set to the vehicles. Thus, the newly set charging current value is notified (S33) from the communication unit 35 to the individual charger 2, and the control from S21 to S33 is repeatedly performed at intervals of a predetermined period to control the charging current.

Thus, the charging current is reduced starting from the vehicle 4 having the smallest charge amount among the vehicles 4 with the charge amount that has exceeded the threshold. Therefore, the vehicle 4 with the charge amount equal to or less than the threshold, which starts charging later, is less likely to be affected by the current reduction control. In addition, the charge amount of the vehicle 4 that starts charging later does not exceed the charge amount of the vehicle 4 that has started charging previously. Accordingly, since the charge of the vehicle 4 having the charge amount equal to or less than the threshold is prioritized, the user having the vehicle 4 that takes long time to be charged does not complain.

[0027]

Meanwhile, when the deviation information is negative, that is, when the received power has not reached the standard value, a control to increase the charging current is performed.

Specifically, the current value (a margin value) allowed to be increased is calculated by the following Formula 3 (S28), and the charging current is increased in the order starting from the vehicle 4 which has the largest charge amount to the vehicle 4 which has the smallest charge amount among the vehicles 4 having the charge amount equal to or less than the threshold (S29).

$$\text{Margin value} = -\text{Deviation information}/\text{Voltage} \quad \bullet\bullet\bullet \text{ (Formula 3)}$$

[0028]

It should be noted that the maximum amount of increase per vehicle is smaller one of a value obtained by subtracting the present current value from a predetermined maximum charging current value or the calculated margin value (S30). For example, when the value obtained by subtracting the present current value from the maximum charging current value is 5 amperes and the margin value is 10 amperes, 5 amperes are selected, and the control to increase the charging current of the first vehicle 4, which is the largest in charge amount among the vehicles 4 having the charge amount equal to or less than the threshold, by 5 amperes is performed.

Thus, the charging current is increased starting from the vehicle 4 having the largest charge amount among the vehicles 4 having the charge amounts equal to or less than the threshold. Accordingly, the charge amount of the vehicle 4 that starts charging later does not exceed the charge amount of the vehicle that has started charging previously, and the user having the vehicle 4 that takes long time to be charged does not complain.

[0029]

Then, a current value obtained by subtracting the increased current value from the margin value is set as a new margin value (S31), steps S29 to S32 are repeated until the margin value becomes 0 or the processes are performed on all of the vehicles 4. The control is performed in the orders set to the vehicles. Thus, the newly set charging current value is notified to the individual charger 2 (S33), and the charge is controlled.

[0030]

Thus, while the demand control that restricts the received power of the commercial power is performed, the vehicle 4 having the charge amount equal to or less than the threshold is preferentially charged. Accordingly, the charging period up to the threshold can be shortened, and even in the situation in which the entire current is restricted, stress felt by the user can be reduced.

Even without obtaining the full charge information from the vehicle 4, whether the vehicle 4 is fully charged can be determined from the current information supplied from the charger 2 and the charge can be terminated. Accordingly, the fully charged vehicle 4 can be reliably removed from the charge target and efficient vehicle charge can be performed.

Even when the demand control that restricts the electric power received from the system is

performed, the vehicle 4 having the charge amount equal to or less than the threshold is preferentially charged. Accordingly, the charging period of charging for traveling a certain distance can be shortened, and stress felt by the user can be reduced even in a situation in which the entire current is restricted.

Further, the vehicle 4 having the charge amount equal to or less than the threshold is less likely to be affected by the current reduction control, and the charge up to the threshold is prioritized. Additionally, when the received power is equal to or less than the standard value and has a reserve power, the charging current of the vehicle 4 having the charge amount equal to or less than the threshold is increased first, and therefore the charging period reaching the threshold can be shortened and a convenience is satisfactory.

[0031]

While the priorities are allocated based on the charge amounts in the embodiment described above, the priorities may be allocated based on the charging periods. In the case, the allocation can be performed by changing "DESCENDING ORDER OF CHARGE AMOUNTS" at S3 and S4 in FIG. 2 to "DESCENDING ORDER OF CHARGING PERIODS."

The effect similar to the above-described embodiment can also be obtained by this control. That is, to reduce the charging current, the charging current is reduced starting from the vehicle 4 having the shortest charging period among the vehicles 4 having the charge amount that has exceeded the threshold. Therefore, the charge amount of the vehicle 4 that starts charging later does not exceed the charge amount of the vehicle 4 that has started charging previously, and thus the user having the vehicle 4 that takes long time to be charged does not complain.

Additionally, to increase the charging current, the charging current is increased starting from the vehicle 4 having the longest charging period among the vehicles 4 having the charge amounts equal to or less than the threshold. Therefore, the charge amount of the vehicle 4 that starts charging later does not exceed the charge amount of the vehicle 4 that has started charging previously, and thus the user having the vehicle 4 that takes long time to be charged does not complain.

It is explicitly stated that all features disclosed in the description and/or the claims are

intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

REFERENCE SIGNS LIST

[0032]

1... Vehicle charging apparatus

2... Charger

3... Charge control unit

4... Vehicle

10... Electric energy meter

31... Measurement unit

34... Charge control unit CPU

35... Communication unit

CLAIMS

1. A vehicle charging apparatus comprising:
 - a plurality of chargers for charging vehicles; and
 - a charge control unit that collectively controls charging currents of the chargers, wherein
 - the charge control unit provides a threshold of a charge amount to set priority order for the vehicles to be charged, the charge control unit performs a charge control that preferentially charges the vehicle having the charge amount equal to or less than the threshold over the vehicle having been charged to exceed the threshold,
 - the charge control unit obtains received power information from a system and controls vehicle charge such that a received power does not exceed a standard value, and
 - the charge control unit removes the vehicle having continued to receive the charging current, which is actually supplied from the charger, smaller than a command value of the charging current for a predetermined period, from a charge target.
2. The vehicle charging apparatus according to claim 1, wherein
 - when the received power is predicted to exceed the standard value, the charge control unit performs a control to reduce the charging current starting from the vehicle having the charge amount that has exceeded the threshold.
3. The vehicle charging apparatus according to claim 2, wherein
 - the charge control unit allocates the priorities in descending order of the charge amounts in a group of the vehicles having the charge amount that has exceeded the threshold, and the charge control unit reduces the charging current starting from the vehicle having a lowest priority in the group.
4. The vehicle charging apparatus according to claim 2, wherein
 - the charge control unit allocates the priorities in order of long charging periods in a group of the vehicles having the charge amount that has exceeded the threshold, and the charge control unit

reduces the charging current starting from the vehicle having a lowest priority in the group.

5. The vehicle charging apparatus according to any one of claims 1 to 4, wherein
when the received power falls below the standard value, the charge control unit performs a control that increases the charging current starting from the vehicle having the charge amount equal to or less than the threshold.

6. The vehicle charging apparatus according to claim 5, wherein
the charge control unit allocates the priorities in descending order of the charge amounts in a group of the vehicles having the charge amount equal to or less than the threshold, and the charge control unit increases the charging current starting from the vehicle having a highest priority in the group.

7. The vehicle charging apparatus according to claim 5, wherein
the charge control unit allocates the priorities in order of long charging periods in a group of the vehicles having the charge amount equal to or less than the threshold, and the charge control unit increases the charging current starting from the vehicle having a highest priority in the group.